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DAGOR DIVING LUNG SECOND EVALUATION.(U)

AUG 56 C M GOGGESHALL

UNCLASSIFIED NEDU-EVALUATION-5-57 NL

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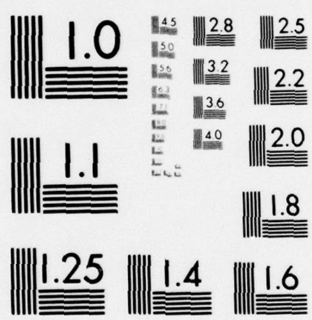
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NAVY EXPERIMENTAL DIVING UNIT

NAVY EXPERIMENTAL DIVING UNIT
BLDG. 214, WASHINGTON NAVY YARD
WASHINGTON, D.C. 20374

EVALUATION REPORT 5-57

DAGOR DIVING LUNG
SECOND EVALUATION

PROJECT NS185-005 SUBTASK 4 TEST 30

C.M. GOGGESHALL
1 August 1956

CONDUCTED
AND
PREPARED

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SUBMITTED

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APPROVED

M. des GRANGES
CDR, USN
Officer in Charge
8 August 1956

ABSTRACT

This report covers the evaluation of the Dacor Diving Lung Regulator to determine the suitablity of the apparatus for use in the Naval service to depths of 200 feet at work rates equivalent to 0.85-knot swimming.

For the description of the demand regulator in detail, see Evaluation Report 11-56. The regulator was tested objectively by breathing machine runs and subjectively by depth runs, with instrumentation for respiratory pressure, respiratory minute volume, and breathing rate. Subjective swimming peak tests covered in Evaluation Report 11-56, were not repeated here. Breathing machine and subjective depth runs are summarized as graphs of peak respiratory pressure, respiratory minute volume, and respiratory rate against time. The results are discussed constructively and lead to specific conclusions about the apparatus and its suitability for Naval service.

SUMMARY

PROBLEM

Is the Dacor Diving Lung Regulator suitable for use in the Naval service to depths of 200 feet at work rates equivalent to 0.85-knot swimming?

FINDINGS

The general findings of Evaluation Report 11-56 remain unchanged except for suitability. The following specific findings apply to this evaluation:

(1) The small check valves are responsible for much of the breathing resistance at depth.

(2) The regulator will sustain 0.85-knot and 1.3-knot swimming to depths of 200 feet.

(3) The regulator meets EDU laboratory criteria of suitability for use in the Naval service.

INFORMATION TO BE WITHELD

5.3 Depth swimming runs

5.3.7 Since criteria for depth swimming tests have not been firmly fixed, the results of these runs must be considered acceptable. However the inhalation pressure on the spurt runs are much higher than usual for this type of run. It is probable that future tests should specify an inhalation pressure limit of 20 cm at 200 feet when the cylinder pressure is above 1000 psi and the respiratory minute volume is under 40 liters.

ADMINISTRATIVE INFORMATION

Ref: (a) EDU Evaluation Report 11-56, "Evaluation of Dacor Diving Lung" for use in the Naval service.
(b) BuShips ltr S94/1(588) ser 588-923 of 6 April 1956
(c) Dacor Corp. ltr SMD/ab to BuShips dated 31 March 1956

Reference (a) is the previous evaluation of the Dacor Diving Lung. Reference (b) established this project. Reference (c) stated that the company had shipped the regulator.

The Decor Diving Lung, Class 1 Open-Circuit Demand Diving Apparatus was evaluated once before at this activity. The evaluations were reported in reference (a). Because the first report was not favorable, the company requested futher evaluation of the apparatus.

The Experimental Diving Unit received two Dacor Diving Lung Regulators complete with breathing tubes and mouthpieces.

C. M. GOGGESHALL, GM2(DV), USN was designated Project Engineer. Work commenced 9 April, 1956 and was completed 15 May 1956. The following breakdown indicates the manhours expended for this project:

DESCRIPTION	MANHOURS
Breathing machine tests	2
Depth swimmings runs	40
Drafting and photography	8
Reporting manuscript	30
Duplicating	6
TOTAL	86

The manuscript was submitted for review 1 August 1956, and was accepted 8 August 1956. This report is issued in the Evaluation Report series, distributed only by the Bureau of Ships. It is the second and final report for this project.

CONTENTS

1. OBJECT

1.1 Objective

This report covers the second evaluation of the Dacor Diving Lung Regulator, to determine the suitability of the apparatus for use in the naval service.

1.2 Scope

This report covers a special limited evaluation, which included an objective breathing machine test to 132 feet and subjective runs to 150 and 200 feet at work rates equivalent to 0.85- and 1.31-knot swimming.

2. DESCRIPTION

2.1 General

2.1.1 For the complete description of the regulator, breathing tubes, and mouthpiece refer to the following articles in Evaluation Report 11-56:

(a) Demand regulator - 2.2.1 through 2.2.10

(b) Mouthpiece and tubes - 2.3.1 through 2.3.5

(c) Photographs - 7.1.3 through 7.1.5

2.1.2 The two regulators furnished were, except for serial numbers and pressure settings, identical to the regulator evaluated in ER 11-56.

3. PROCEDURE

3.1 Breathing machine tests

3.1.1 The breathing machine was set at 2 liters per breath and 20 breaths per minute.

3.1.2 The 1-psi strain gage was rigged in the recompression chamber. The analyzer was calibrated and the attenuation was set to give on line deflection for one centimeter of water pressure. On the recording tape the following was noted: Dacor Diving Lung Regulator, date, calibration, attenuation, and the direction of deflection for inhalation.

3.1.3 For these tests the Dacor regulator was mounted on a standard two-cylinder test manifold. The cylinders were charged to 1800 psi cool, the valves were opened, and the apparatus was placed in the chamber. The air reserve device was cut into the high pressure circuit.

3.1.4 A 3000-psi mechanical gage was rigged to the apparatus manifold. It was set in the chamber port so as to be visible from the outside.

3.1.5 The mouthpiece connector was inserted into the mouthpiece and taped securely. The pressure tap on the mouthpiece was connected to the signal side of the strain gage. The reference side was opened to the chamber, and then the chamber door was closed.

3.1.6 The breathing machine was started, and the breathing pressure recorder was turned on. The chamber was taken down to 132 feet at a rate of 20 ft per min. The analyzer operator marked every ten ft and every atmosphere on the recording tape. He also entered ever 100 psi increment of falling cylinder pressure on the tape. At 132 ft the breathing machine was stopped and the breathing pressure analyzer was balanced.

3.1.7 The breathing machine was restarted. The chamber was returned to the surface at a rate of 20 ft per min. The operator marked every ten ft and every atmosphere on the recording tape. On the surface the breathing machine was stopped, and the breathing pressure analyzer was checked for balance and calibration.

3.2 Special check valve runs

3.2.1 Evaluation Report 11-56 concluded that the Diving Lung check valves are probably too small for satisfactory depth resistance, but did not substantiate the conclusions with concrete data. To investigate this point, a special series of runs was made to compare regulator performance with and without the check valves.

3.2.2 Two runs were made on the Diving Lung mouthpiece and check valves without breathing tubes or regulator, one run at the surface and the other at 132 ft. For comparison, two similar runs were made on a satisfactory set of check valves and mouthpiece.

3.2.3 Two more runs were made at 132 ft, one on the complete regulator assembly with check valves, and the other on the complete assembly without check valves.

3.2.4 All of these runs were made at the standard breathing machine setting of 2 lpb and 20 bpm, with breathing pressure instrumentation as in Sec. 3.1.

3.3 Depth swimming tests

3.3.1 For these runs the Dacor regulator was mounted on the standard two-cylinder test set charged to 1800 psi cool. The following description applies to the standard swim runs at 150 feet.

3.3.2 During the descent, the apparatus was not used by the subject. Upon reaching the bottom, the subject donned the apparatus, and assumed his position on the trapeze. The remainder of the first 5 min. was used to adjust the instruments. At 5 min the subject started to swim on the trapeze against an 8 lb. pull (equivalent to 0.85 of a knot), and swam at this rate for 10 min. At this time the subject was shifted to a 6 lb. pull (equivalent to 0.78 of a knot), he swam at this rate for 13 min, whereupon he was shifted to another breathing apparatus to attain evaluation data for another project.

3.3.3 Four runs were made at 150 feet, and two runs were made at 200 ft. Ascent was made at 60 ft per minute; and decompression was given according to new tables being evaluated. Total bottom time for the 150-foot runs was 30 min. Total bottom time for the 200-foot runs was 15 minutes. The descent time was limited to 5 minutes for both the 150- and 200-foot runs.

3.3.4 Three 150 foot runs were made at the standard swim rate (8-pound pull) for 10 minutes, and the light swim rate (6-pound pull) for 13 minutes.

3.3.5 One 150-foot run was made at the spurt swim rate (12-pound pull equivalent to 1.32 of a knot) for 10 minutes, and light swim rate (6-pound pull) for 13 minutes.

3.3.6 One 200-foot run was made at the standard swim rate (8-pound pull) for 10 minutes on the bottom. At the end of bottom time the subject shifted to the light swim rate (6-pound pull) for the ascent only. The remainder of the runs was a rest period for decompression. The apparatus was not shifted for decompression.

3.3.7 The other 200-foot run was made at the spurt swim rate (12-pound pull) for 10 minutes on the bottom. The procedure for the remainder of the run was the same as in 3.3.6.

3.4 Depth run instrumentation

3.4.1 A 1-psi differential strain gage, with the signal side tapped into the mouthpiece tee, was used to measure breathing pressures. The reference side was connected to a bubbler terminating at the demand regulator, with the open end down. Bubbling was kept to a minimal amount. The analyzer was calibrated before the run, and calibration was re-checked after the run. The analyzer was balanced before the run, upon starting the swim, at 8 minutes and every 4 minutes after, except during ascent. Breathing pressures were recorded from the start of the swim until complete exhaustion of the air supply occurred or until breathing pressures reached a 40-centimeter high.

3.4.2 Because of instrumentation difficulties, cylinder pressures were not recorded in these runs.

3.4.3 On all subjective depth runs, the exhaled gas was trapped and led through a gas meter for measurement. The exhaled volume was recorded automatically.

3.4.4 The following information was recorded at the beginning and end of each strain gage taps: subject, equipment, date, calibration, attenuation and direction of deflection for inhaltion.

3.5 Pool tests

3.5.1 Because there was no basic change in the apparatus, pool tests were not considered necessary for this second evaluation of the Dacor Diving Lung Regulator.

3.5.2 Complete pool test prodedure and results are given in Evaluation Report 11-56.

4. RESULTS

4.1 Breathing machine tests

4.1.1 Figure M-1 is a graph of run 1 on the breathing machine.

4.1.2 The graph shows inhalation pressure, exhalation pressure, and cylinder pressure against depth.

4.1.3 The solid lines indicate pressure during descent; the broken lines, during ascent.

4.2 Special check valve runs

4.2.1 Figures T-1 and T-2 are pertinent parts of the breathing machine tapes for the Diving Lung mouthpiece and check valves.

4.2.2 Figures T-3 and T-4 are pertinent parts of the breathing machine tapes for a satisfactory mouthpiece and check valves.

4.2.3 Figures T-5 is a pertinent section of the breathing machine tape for the complete regulator assembly including check valves.

4.2.4 Figure T-6 is a pertinent section of the breathing machine tape for the complete regulator assembly without check valves.

4.3 Subjective depth runs

4.3.1 Figures D-1 to D-3 are graphs of the three sujective depth runs to 150 feet at the standard swim rate. Figure D-4 is a graph of the subjective depth run to 150 feet at the spurt swim rate. Figure D-5 is the graph of the subjective depth run to 200 feet at the standard swim rate. Figure D-6 is a graph of the subjective depth run to 200 feet at the spurt swim rate.

4.3.2 All graphs are plotted against time, and show:

(1) Inhalation pressure
(2) Exhalation pressure
(3) Respiratory minute volume
(4) Respiratory rate

5. DISCUSSION

5.1 Breathing machine tests

5.1.1 Figure M-1 indicates that the Dacor Diving Lung satisfactorily meets the criteria for laboratory evaluation standards at the Experimental Diving Unit. Inhalation and exhalation pressures did not exceed 10 cm of water at the surface or 20 cm of water at 132 feet.

5.1.2 During this run the cylinder pressure did not drop below 900 psi. The criteria calls for a drop to 500 psi. However the functioning of the regulator is nearly independent of the cylinder pressure (Evaluation Report 11-56, Article 5.2.3).

5.2 Special check valve runs

5.2.1 Comparison of figure T-1 and T-3 shows that the Diving Lung check valve arrangement requires high breathing pressure even at the surface. Inhalation and exhalation both produce 4 cm of water (Figure T-1). In the other arrangement inhalation produces 2 1/2 cm and exhalation produces 1 1/2 cm.

5.2.2 Comparison of figures T-2 and T-4 shows that the Diving Lung check valve arrangement requires very high breathing pressure at 132 feet. Inhalation produces 10 cm of water and exhalation produces 12 cm of water (Figure T-2). In the other arrangement inhalation produces 5 cm of water and exhalation produces 2 cm of water.

5.2.3 Comparison of figure T-5 and T-6 shows that at 132 feet the check valves do not materially affect the already high inhalation pressure, but that they add about 5 cm to the 16 cm exhalation pressure.

5.2.4 These results indicate that the check valves themselves are too small and are responsible for much of the breathing resistance at depth. In conjunction with other components, their effect is not extreme, however. The performance at 900 psi in this evaluation may safely be extrapolated to 500 psi.

5.3 Depth swimming tests

5.3.1 Table 5-1 on the next page is a comparative summary of the important data appearing in figures D-1 through D-6.

5.3.2 Where inhalation pressures fluctuated around some particular value, the "average" inhalation peak pressure was estimated (not calculated) for the period indicated. The period 5-15 minutes covers the work time on the 8 or 12-pound pull at depth. Where inhalation pressure did not stabilize, no "average" is given.

5.3.3 Runs 1 through 3 were made at 150 feet at the standard swim rate. Of the 3 runs, all remained within acceptable inhalation pressure limits. These results indicate that the Dacor Diving Lung regulator is satisfactory of 0.85-knot swimming at 150 feet.

5.3.4 Run 4 was made at 150 ft at the spurt swim rate. In this run the inhalation pressure climbed to a peak of 34 centimeters. This result indicates that the Dacor Diving Lung regulator will sustain 1.3-knot swimming at 150 feet.

TABLE 5-1

COMPARATIVE SUMMARY OF INDIVIDUAL RESULTS

RUNS	TIME	INHALATION		MAXIMUM INHALATION		MAXIMUM EXHALATION		RMV		RESP. RATE	
	(min.)	5-15	15-28	PRESS	TIME	PRESS	TIME	PRESS	TIME	PRESS	TIME
1	27	13	14	20	23	35	7	25	14	12	11
2	28	21	23	25	12	16	7	15	15	10	10
3	28	16	19	22	12	28	14	25	14	14	14
4	28	27	22	34	12	20	15	30	13	14	15
5	36	17	*	22	10	32	10	21	15	6	15
6	36	27	*	33	12	35	11	38	15	18	13

*Period of ascent

TABLE 5-1

5.3.5 Run 5 was made at 200 feet at the standard swim rate. Inhalation pressures reached 22 centimeters. This indicates that the Dacor Diving Lung regulator will sustain 0.85-knot swimming at 200 feet.

5.3.6 Run 6 was made at 200 feet at the spurt swim rate. Inhalation pressure reached 33 centimeters. This indicates that the Dacor Diving Lung regulator will sustain 1.3-knot swimming at 200 feet.

6. CONCLUSIONS

6.1 Characteristics

6.1.1 The conclusions of Evaluation Report 11-56 concerning the Dacor Diving Lung demand regulator itself (6.1.1 (1) through (4)) remain unchanged.

6.1.2 The conclusions of Evaluation Report 11-56 concerning the complete Dacor Diving Lung apparatus (6.1.2 (1) and (2) still apply. The small non-return check valves are responsible for much of the breathing resistance at depth (5.2.4).

6.2 Suitability

(1) The regulator will sustain 0.85-knot and 1.3-knot swimming to depth of 200 feet (5.3.3-5.3.6).

(2) The Dacor Diving Lung demand regulator meets EDU laboratory criteria of suitability for use in the Naval service.

7. FIGURES

7.1 Breathing machine run

Figure M-1 shows the breathing pressure and cylinder pressure against depth to 132 feet and back to the surface. The reserve device was cut out of the circuit.

7.2 Special check valve runs

7.2.1 Figures T-1 and T-2 show the runs using the Diving Lung mouthpiece and check valves without breathing tubes or regulator. T-1 was a surface run and T-2 was a 132-foot depth run.

7.2.2 Figures T-3 and T-4 show the runs using a satisfactory set of check valves and mouthpiece. T-3 was a surface run and T-4 was a 132-foot depth run.

7.2.3 Figures T-5 and T-6 runs were both made at 132 feet. Figure T-5 shows the results on the complete regulator assembly with check valves & Figure T-6 shows the results on the complete assembly without check valves.

7.3 Depth swimming runs

7.3.1 Figures D-1 to D-3 show data for the standard (0.85-knot) swimming runs at 150 feet.

7.3.2 Figure D-4 shows the data for the spurt (1.3-knot) swimming run at 150 feet.

7.3.3 Figure D-5 shows the data for the standard (0.85-knot) swimming run at 200 feet.

7.3.4 Figure D-6 shows the data for the spurt (1.3-knot) swimming runs at 200 feet.

BREATHING PRESSURES—CM OF WATER

FIG. T-1

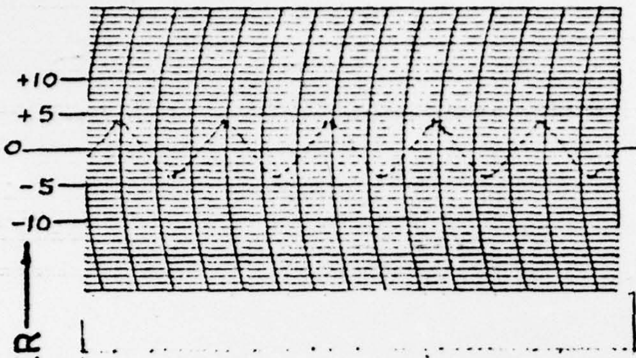


FIG. T-3

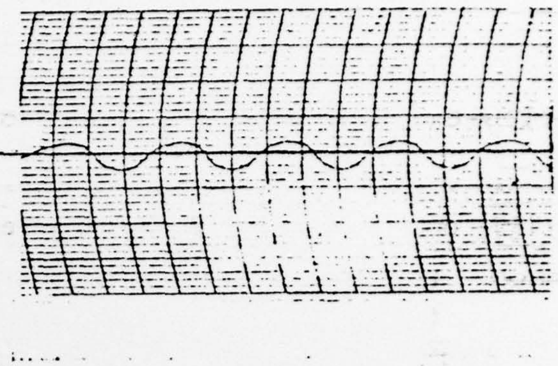


FIG. T-2

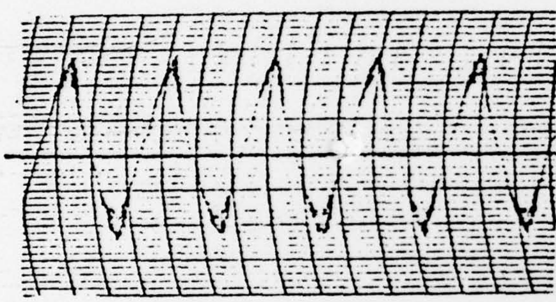


FIG. T-4

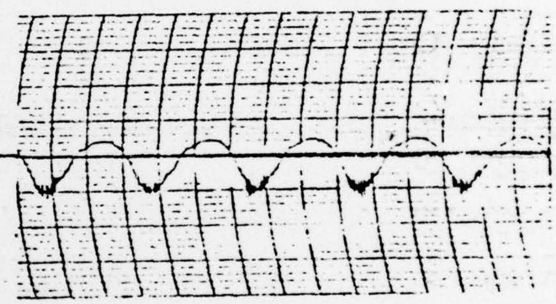


FIG. T-5

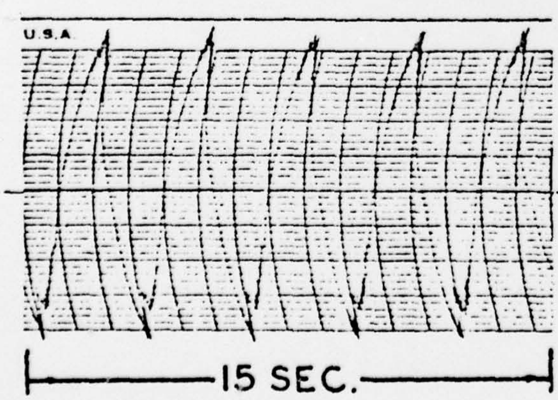
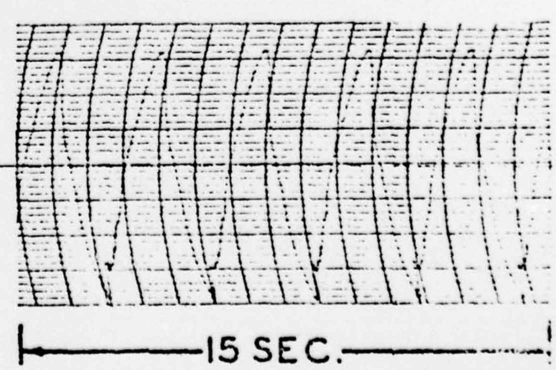
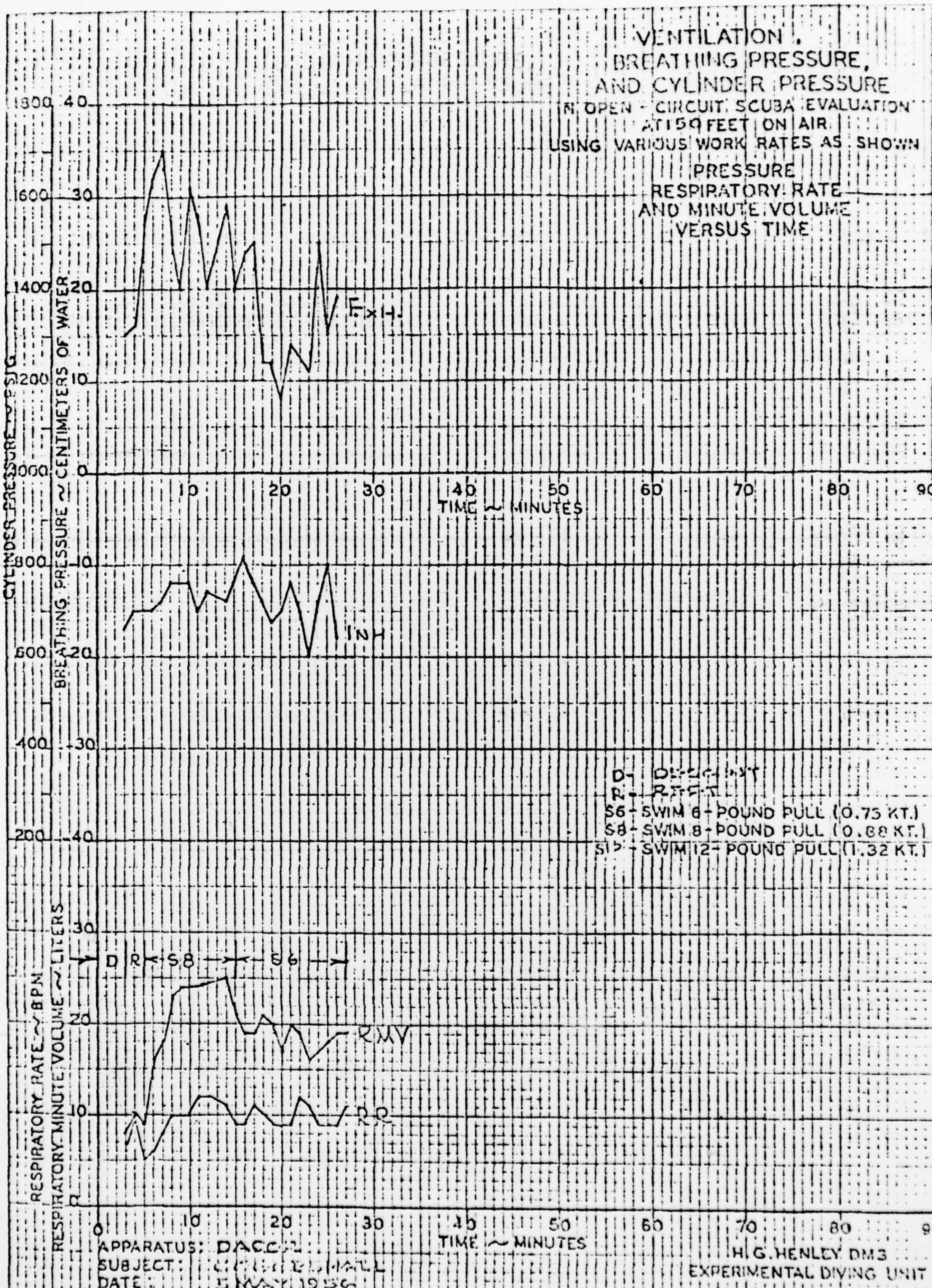


FIG. T-6





VENTILATION, BREATHING PRESSURE, AND CYLINDER PRESSURE
IN OPEN - CIRCUIT SCUBA EVALUATION
AT 150 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
EXH.
INH.
TIME ~ MINUTES
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.88 KT.)
SWIM 12 - POUND PULL (1.32 KT.)
D
R
S8
S6
RMV
RR
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
APPARATUS:
SUBJECT:
DATE:
H G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

Fig. D-1

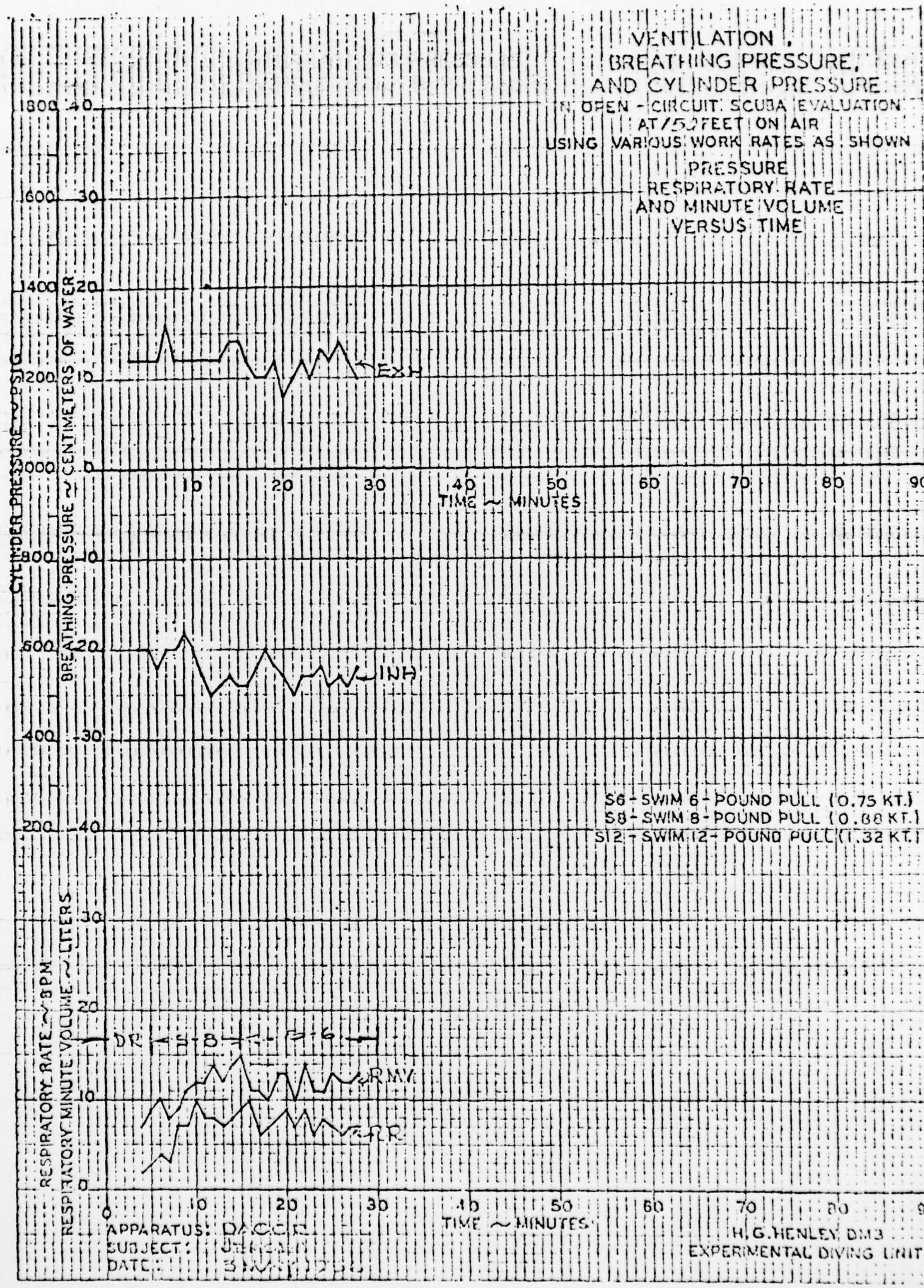
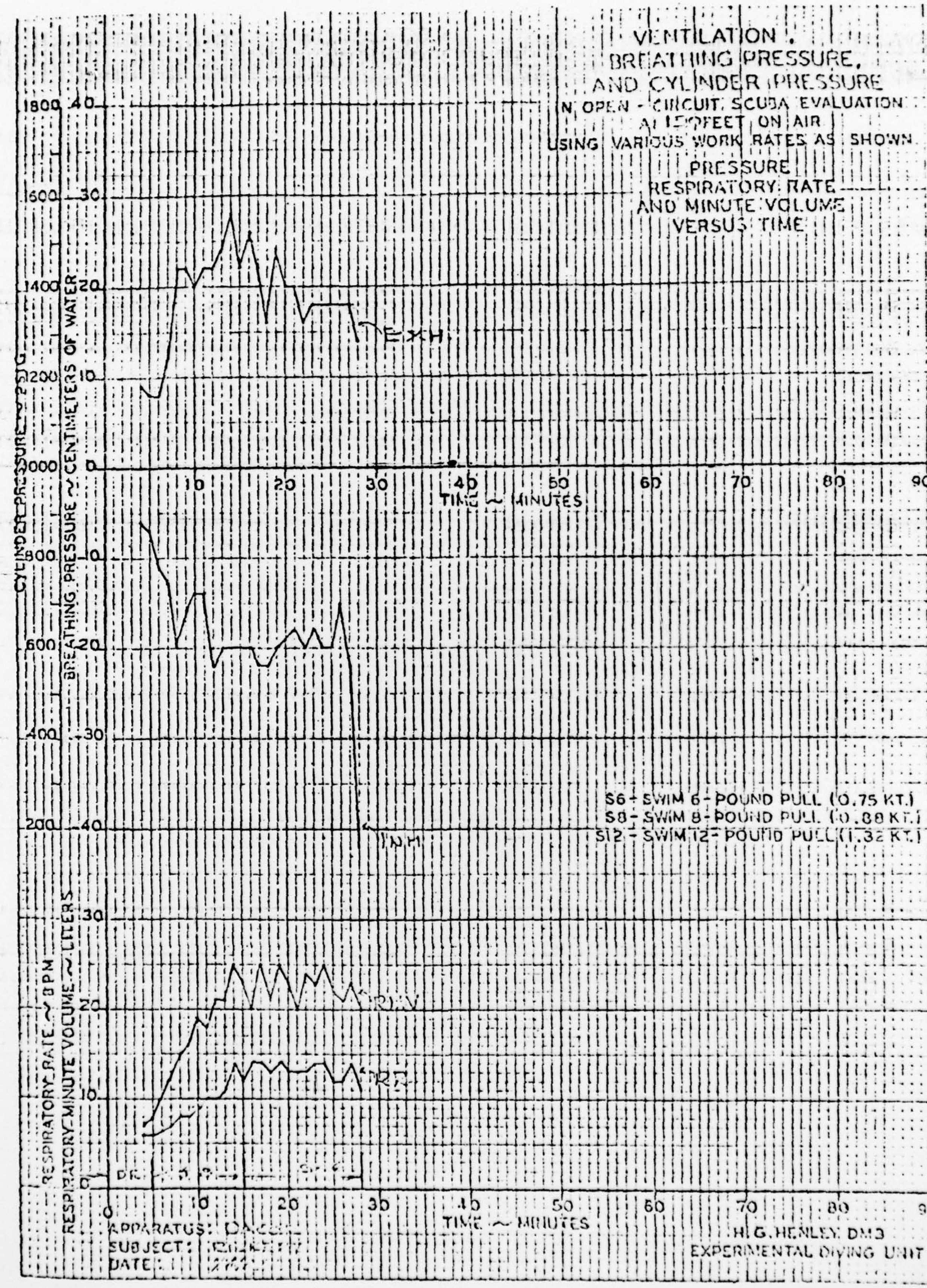
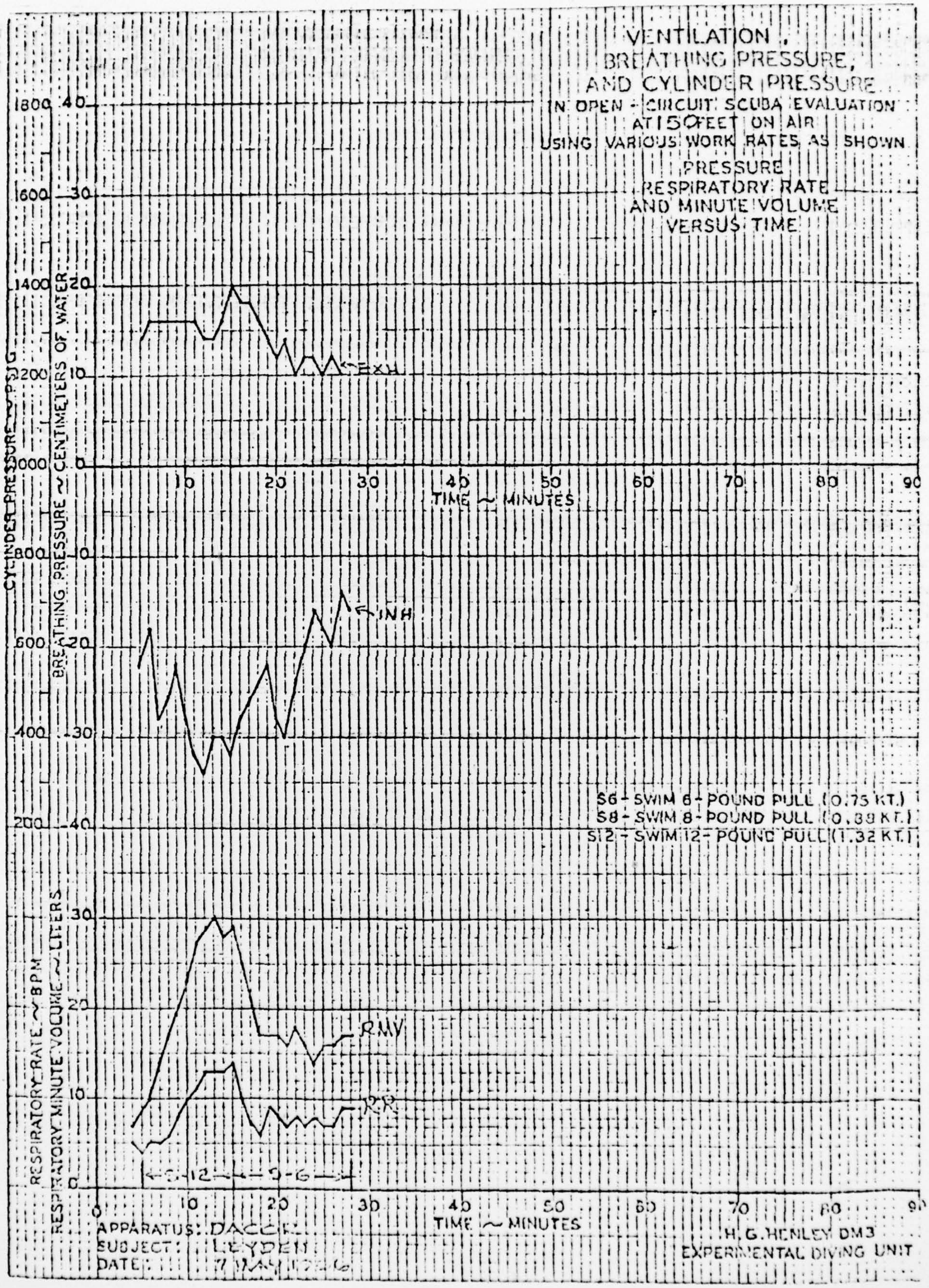

VENTILATION, BREATHING PRESSURE, AND CYLINDER PRESSURE
IN OPEN - CIRCUIT SCUBA EVALUATION
USING VARIOUS WORK RATES AS SHOWN
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
TIME ~ MINUTES
EXH
INH
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.88 KT.)
S12 - SWIM 12 - POUND PULL (1.32 KT.)
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
RMV
RR
APPARATUS:
SUBJECT:
DATE:
H. G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

Fig. D-2.



VENTILATION,
BREATHING PRESSURE,
AND CYLINDER PRESSURE
N OPEN - CIRCUIT SCUBA EVALUATION
AT 150 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN.
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
EXH
INH
TIME ~ MINUTES
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.88 KT.)
S12 - SWIM 12 - POUND PULL (1.32 KT.)
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
RMV
RR
TIME ~ MINUTES
APPARATUS:
SUBJECT:
DATE:
H. G. HENLEY DMD
EXPERIMENTAL DIVING UNIT

Fig. D-3



VENTILATION, BREATHING PRESSURE, AND CYLINDER PRESSURE IN OPEN - CIRCUIT SCUBA EVALUATION AT 150 FEET ON AIR USING VARIOUS WORK RATES AS SHOWN
PRESSURE RESPIRATORY RATE AND MINUTE VOLUME VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
EXH
INH
TIME ~ MINUTES
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.89 KT.)
S12 - SWIM 12 - POUND PULL (1.32 KT.)
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
RMV
RR
S-12
S-6
APPARATUS: DACOR
SUBJECT: LEYDEN
DATE: 7 MAY 1956
H. G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

Fig. D-4

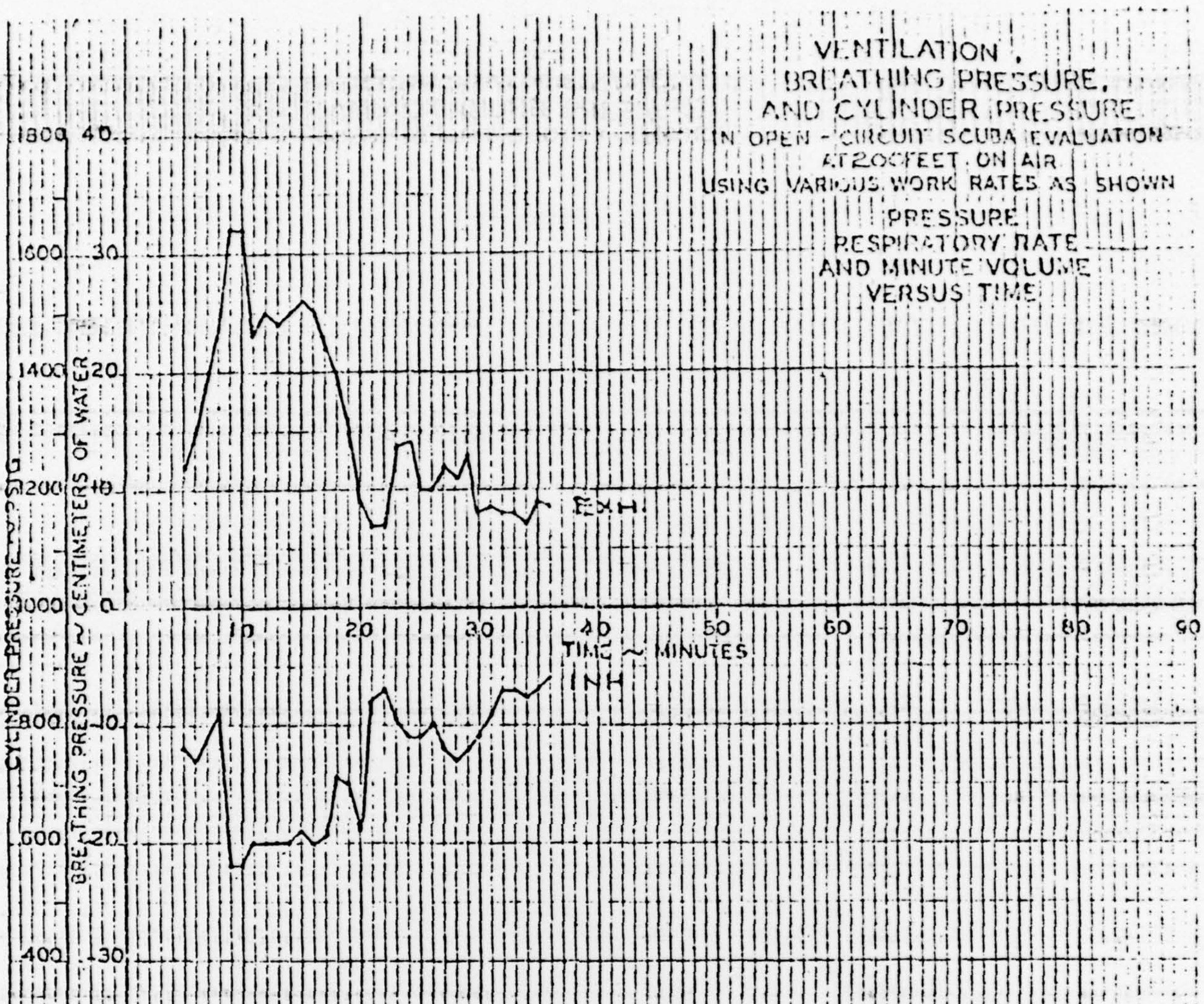

VENTILATION,
BREATHING PRESSURE,
AND CYLINDER PRESSURE
IN OPEN - CIRCUIT SCUBA EVALUATION
AT 200 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
EXH.
INH
TIME ~ MINUTES
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.89 KT.)
S12 - SWIM 12 - POUND PULL (1.32 KT.)
D
S8
A
S6
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
RMV
RR
APPARATUS:
SUBJECT:
DATE:
H. G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

Fig. D-5

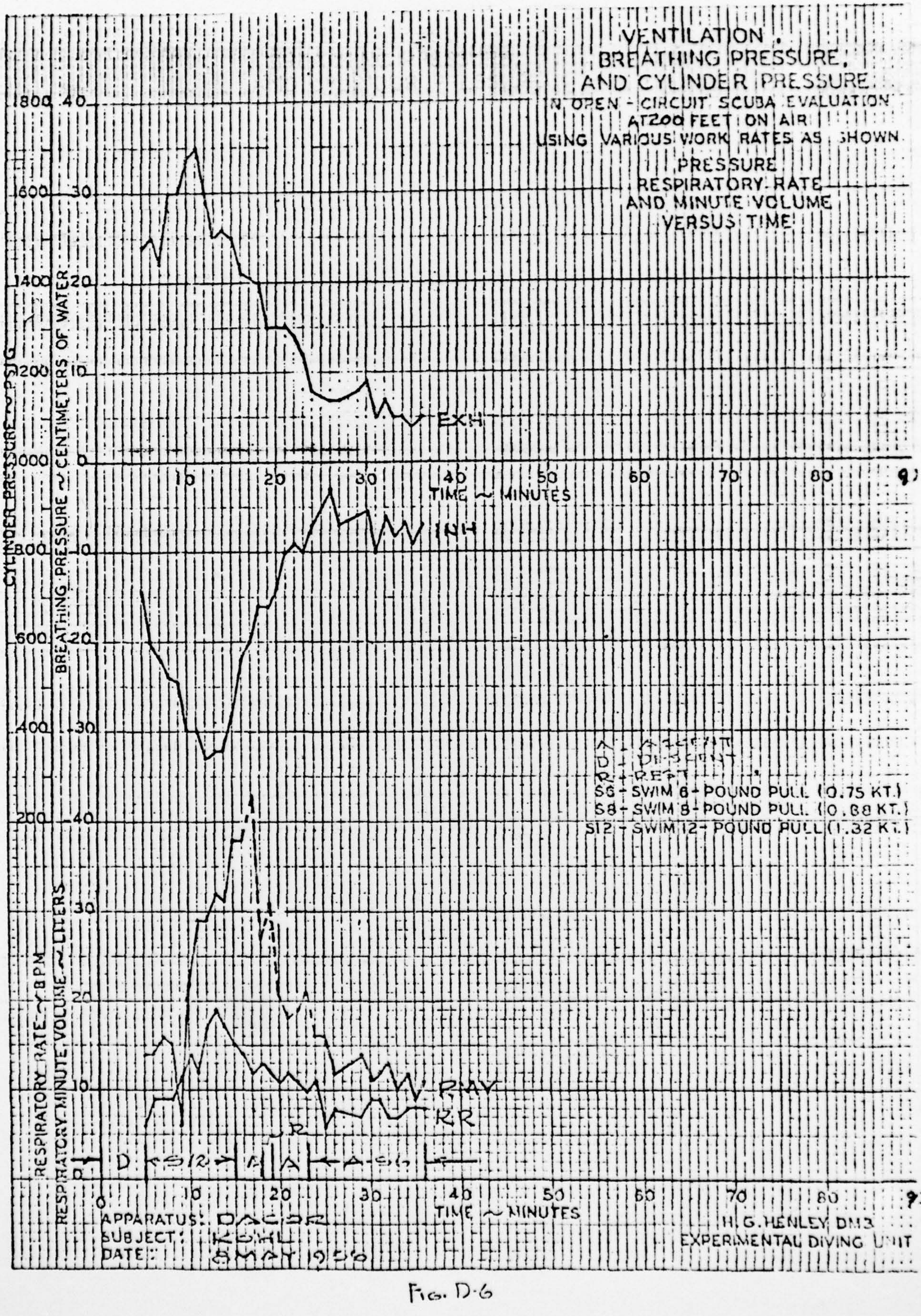
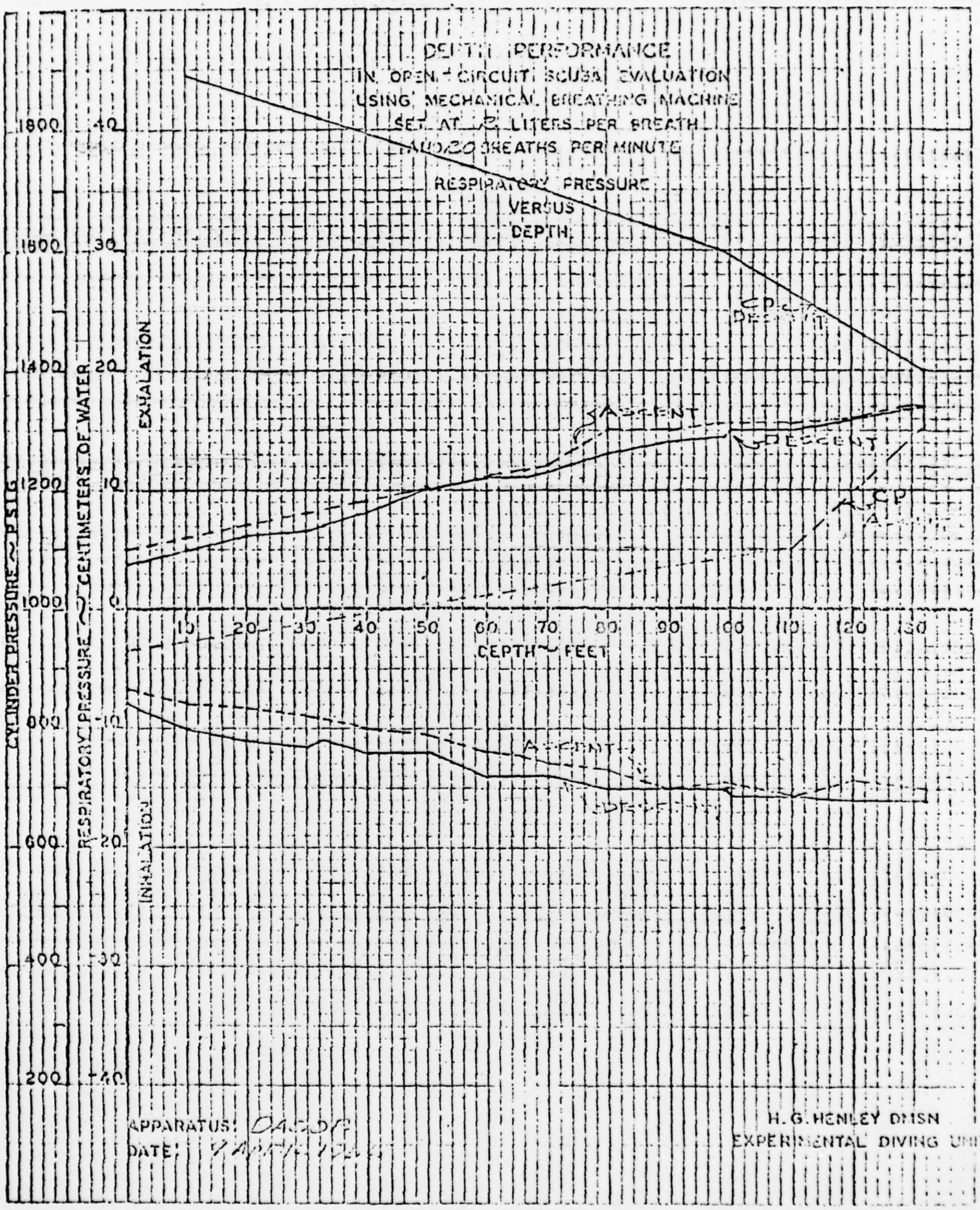

VENTILATION,
BREATHING PRESSURE,
AND CYLINDER PRESSURE
IN OPEN - CIRCUIT SCUBA EVALUATION
AT 200 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUME
VERSUS TIME
CYLINDER PRESSURE ~ PSIG
BREATHING PRESSURE ~ CENTIMETERS OF WATER
TIME ~ MINUTES
EXH
INH
S6 - SWIM 6 - POUND PULL (0.75 KT.)
S8 - SWIM 8 - POUND PULL (0.88 KT.)
S12 - SWIM 12 - POUND PULL (1.32 KT.)
RESPIRATORY RATE ~ BPM
RESPIRATORY MINUTE VOLUME ~ LITERS
RMV
RR
APPARATUS:
SUBJECT:
DATE:
H. G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

Fig. D-6


DEPTH PERFORMANCE
IN OPEN CIRCUIT SCUBA EVALUATION
USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH
AND 20 BREATHS PER MINUTE
RESPIRATORY PRESSURE
VERSUS
DEPTH
CYLINDER PRESSURE ~ P.S.I.G.
RESPIRATORY PRESSURE ~ CENTIMETERS OF WATER
EXHALATION
INHALATION
1800
1600
1400
1200
1000
800
600
400
200
40
30
20
10
0
10
20
30
40
10
20
30
40
50
60
70
80
90
100
110
120
130
DEPTH ~ FEET
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APPARATUS:
DATE:
H. G. HENLEY DMSN
EXPERIMENTAL DIVING UNIT

Fig. M-1

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This report covers the evaluation of the Dacor Diving Lunt Regulator to determine the suitability of the apparatus for use in the Naval service to depths of 200 feet at work rates equivalent to 0.85 knot swimming.

For the description of the demand regulator in detail, see Evaluation Report 11-56. The regulator was tested objectively by breathing machine runs and subjectively by depth runs, with instrumentation for respiratory pressure,
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20. respiratory minute volume, and breathing rate. Subjective swimming peak tests covered in Evaluation Report 11-56, were not repeated here. Breathing machine and subjective depth runs are summarized as graphs of peak respiratory pressure, respiratory minute volume, and respiratory rate against time. The results are discussed constructively and lead to specific conclusions about the apparatus and its suitability for Naval service.